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PROCESS AND ARRANGEMENT FOR THE DETERMINATION OF THE NOISE FACTOR OF ELECTRONIC MEASUREMENT OBJECTS

[Verfahren und Anordnung zum Bestimmen der Rauschzahl von elektronischen Meßobjekten]

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Specification

This invention relates to a process according to the preamble of the main claim as well as a device for the implementation of this process.

Considering the increasingly complex high-frequency and microwave circuits, the testing of the system parameters already on the level of the module, in other words, for example, directly on the used components (resistances, transistors) or the circuit building blocks (integrated circuits) is assuming increasing significance already during the developmental stage. A magnitude that is essential here is the so-called noise factor that expresses the ratio between the signal/noise interval at the input and the signal/noise interval at the output of a measurement object (for example, Meinke Grundlach, 1956, page 1023 ff).

It is known that one can determine the noise factor, for example, according to the so-called 3 dB method (M. Groll, Microwave Measurement Technique, 1969), where the supply of the level necessary for the purpose of doubling the output comes from a sinus generator. This 3 dB method, however, is relatively inaccurate because an absolute level measurement is

[1] Numbers in the margin indicate pagination in the foreign text.

performed here and because the internal noise of the level measurement unit is not considered.

A method, therefore, proved effective in practice where, first of all, the internal noise of the selective level meter employed during the measurement is measured during a calibration step and only then the noise of the measurement object so that during the subsequent analysis procedure, one can consider the internal noise of the level meter. A noise source in the form of a diode is used here for purposes of calibration and for the actual measuring of the noise of the measurement object. If a direct voltage is applied to that diode, then it supplies a first noise output that corresponds to a hot noise temperature of, for example, 10,000 K, [and] without bias voltage, it supplies a noise output corresponding to a cold noise temperature, for example, of 290 K. These two differing noise lines [sic] of the noise source are supplied during calibration directly into the level measurement device and during the actual measurement at the input of the measurement object, and the resultant levels are measured (ntZ Band 43f, 1990, Number 2, pages 84 to 86). From these two predetermined noise temperature values and the noise levels measured during the calibration and measurement procedure, one can then calculate the noise temperature or the noise factor (formula 13 according to ntZ Band 43, Number 2, page 85). This known process, of course,

does take into consideration the internal noise of the selected level meter, but it requires an additional noise source that is relatively expensive with a view to the required decision.

The object of the invention is to provide a process for the determination of the noise factor, which makes such a separate noise source superfluous and nevertheless offers high accuracy; besides, the invention is to point up an arrangement for the implementation of this process, which will have a simple structure.

This problem is solved starting with a process according to the preamble of the main claim by virtue of the latter's characterizing features. The subclaims contain a particularly simple arrangement for the implementation of this process.

The invention uses the realization that in the formulas for the calculation of the noise factor, one can also express the values used in the known method for cold and hot noise temperature also by means of corresponding noise output levels, whereby in the known formulas for this conversion, nothing is stated as to what these output levels must be like. From this realization results the invention-based measure that to determine the noise factor, one does not need the hitherto customary broadband noise output from a separate noise source for the measurement as such, but rather that a level of a sinus generator is also suitable for this. The generation of two

differently sized sinus signal levels on a frequency generator essentially can be made in a simpler manner than the use of a separate diode noise source that can be turned on and turned off. Nevertheless, the measurement is very accurate because one continues to use the known calibration method for the prior determination of the internal noise of the level meter.

The embodiment of the invention-based process by means of a usual spectrum or network channel analyzer with oscillator is particularly advantageous, for example, using the FSAC spectrum analyzer produced by Rohde & Schwarz that has an oscillator (tracking generator) that is synchronized with the frequency-selected level meter, whose output signal can be adjusted via a calibration divider with defined output levels. With this kind of analyzer that is highly sensitive and that offers a level measurement accuracy in a broad frequency band, one can determine the noise factor of any electronic measurement objects such as components, amplifiers and the like in a simple manner in that the output of the oscillator during the calibration procedure is directly connected with the neighboring input of the actual analyzer and that, thereafter, the calibration of the analyzer is performed with two differing output levels, and that subsequently between the output of the oscillator and the input of the analyzers, the measurement object is connected in between, and that, then again, the actual measurement is

performed with the two differing levels. The two differently sized levels can be adjusted in a simple manner via the installed output calibration divider of the oscillator. The magnitude of these two different levels can be freely selected theoretically. The noise outputs added by virtue of the measurement object, however, generally are very small; therefore, these levels should not be too great because, otherwise, the analyzer can no longer resolve the differences between the output signal of the oscillator at the input of the measurement object and the output signal of the measurement object. It is therefore practical to use a frequency generator that makes it possible to adjust very small output levels, such as can be done with the oscillator of the FSAC analyzer with up to -120 dBm. The first signal level of the frequency generator can be adjusted as desired and can thus be adapted to the noise output of the particular measurement output. The invention-based measurement can be implemented practically with any frequency of the total frequency band of the frequency generator, for example, also at low frequencies. The noise factor determination according to the invention when one uses an analyzer with an oscillator is possible not only with selected discrete individual frequency, but an automatic measurement procedure over the entire frequency range of the analyzer is

also possible. The calibration measurement here can be performed either directly during the gradual relaying of the /2 frequency for each individual discrete frequency step prior to the actual object measurement, or in a first calibration procedure, one first of all performs the calibration on the selected measurement points within the total frequency band, and then one does the actual object measurement in a second measurement procedure. The important thing is that during the subsequent evaluation, one considers in each case the calibration values and the measurement values for frequencies that are within the bandwidth B_5 of the level measurement device.

The invention will be explained in greater detail below on the basis of an exemplary embodiment with reference to a diagram.

The figure shows a commercially available spectrum analyzer FSAC by Rohde & Schwarz, described in the data sheet PD756.7142.12 with a frequency-selective level meter S that can be varied in the frequency range between 100 Hz and 2 GHz and a very sensitive high-frequency preamplifier with a low internal noise. The tuning oscillator of the frequency-selective level meter S, working according to the superposition principle that can be automatically varied by a wobble device in the given frequency range, but which, however, can also be adjusted manually to any desired discrete frequency of the entire

frequency range, is synchronized with an oscillator (tracking generator) G that is integrated into the unit, while the output frequency of this oscillator G is available at the exit hub "A" with a precisely determined level that can be adjusted by a built-in calibration divider. The calibration divider is used to set a first very small level P_1 on the order of magnitude of -120 dBm, which is chosen at random in keeping with the particular measurement object M that is to be measured. Besides, on the calibration divider of generator G, one adjusts a level P_2 that is by comparison smaller by a constant value.

During a first calibration measurement, the output A of generator G is directly connected with the input "E" of the level meter S, and in the process, the level measurement values P_{1K} and P_{2K}, corresponding to the internal noise, are measured. Thereupon, the measurement object M, with bandwidth B_M, is inserted between the output of generator G and the input of level meter S, and at the same frequency, the two levels P_1 and P_2 are again supplied and the level measurement values P_{1M} and P_{2M}, appearing at the output of measurement object M, are then measured. Then according to the formula given in the figure, these level values are used to determine the noise temperature T_M, whereby k is the Boltzmann's constant and B_S is the bandwidth of the measurement object. Noise factor F can then be calculated from that in the known manner.

The noise factor measurement according to this method can be determined either with only one single discrete frequency of the oscillator G or with several predetermined frequencies of a range predetermined by the measurement object, although this can also be done automatically by means of the wobble operation of the level meter. In the invention-based method, the levels P_1 and P_2 are sinus voltages of the sinus generator G; therefore, a faster measurement procedure is also guaranteed here because there is no mean value formation in the level meter during calibration.

Claims

1. Method for the determination of the noise factor of an electronic measurement object by level measurement by means of a frequency-selective level meter considering the internal noise of the level meter that is determined during a calibration measurement, **characterized in** that from a sinus generator that can be adjusted for discrete frequencies during the calibration procedure, first of all, a sinus signal with a predetermined first level and then with a predetermined second level is directly supplied into the level meter and that, in the process, the resultant internal noise level of the level meter can be measured, and subsequently, a sinus signal with the same two predetermined levels is supplied into the measurement object, and on the latter's output, the pertinent noise level of the

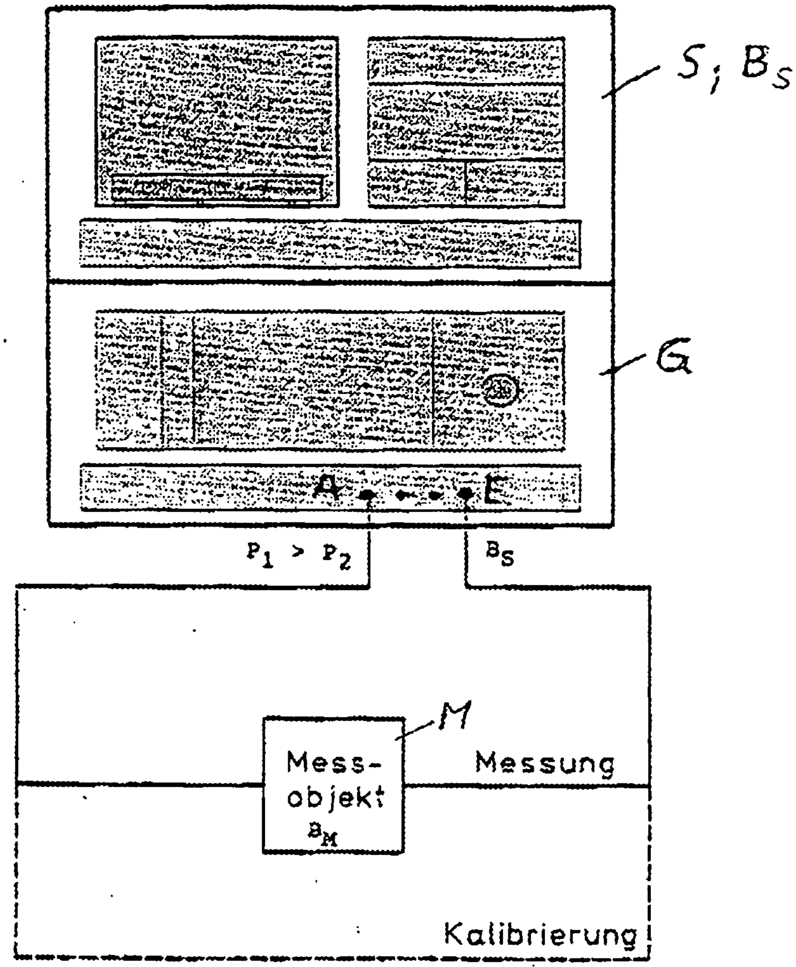
measurement object can be measured and that the noise factor is determined from these supplied and measured levels.

2. Arrangement for the implementation of a method according to Claim 1, characterized by the use of a spectrum or network analyzer with integrated oscillator, whereby the output signal of the oscillator, synchronized with the frequency-selective level meter of the analyzer, can be set at two predetermined different levels.

3. Arrangement according to Claim 2, characterized in that the two differing levels can be adjusted on the output power divider of the oscillator.

1 sheet of drawings

[Please see drawings].



$$T_M = \frac{1}{k \cdot B_S} \; \frac{P_1 \cdot (P_{2M} - P_{2K}) + P_2 \cdot (P_{1K} - P_{1M})}{(P_{1M} - P_{2M})}$$

bei Kalibrierung: P_{1K}, P_{2K} $\qquad B_S < B_M$

mit Meßobjekt: P_{1M}, P_{2M} $\qquad P_1 > P_2$

[Key: 1) Measurement object; 2) Measurement; 3) Calibration; 4) Upon calibration; 5) With measurement object].